Effect of Pre-Harvest Application of Maleic Hydrazide on Growth, Yield and Bolting of Radish (*Raphanus sativus* cv. Tokinashi) During Late Winter Season under Terai Condition of Rupandehi, Nepal

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Abstract

An experiment was conducted at Rupandehi, Nepal from January to March, 2018 with an objective of investigating the effects of different concentrations viz. 0, 0.025, 0.05, 0.1, 0.2, 0.25, 0.3 and 0.5 % of Maleic Hydrazide (MH), foliar sprayed at the rate of 2 litres per 2.4 m^2, 49 days after sowing (DAS) on growth, yield and bolting of radish. Field experiment was laid out in Randomized Complete Block Design (RCBD) with 4 replications. The MH concentration affected % change in plant height and no. of leaves per plant. Maximum root yield was obtained at 0.25% concentration (44.8 t ha^{-1}) and minimum at 0.025% MH concentration (26.07 t ha^{-1}). Bolting was significantly delayed ($p<0.05$) by increasing MH concentration. 0.25% MH concentration was found superior with respect to inhibitive effect on growth parameters, delayed bolting, highest root yield and B:C ration. The result must be replicated several times for proper validation of the results obtained.

Key words: Late winter, Maleic hydrazide, Growth retardation, Bolting delay.

Introduction:

Radish is one of the important and commonly cultivated cool-season root vegetable in Nepal (Poon *et al.*, 2004; Subedi *et al.*, 2018). The crop matures in 3 – 4 weeks in summer and 7 – 8 weeks in winter. Moderate day length with cool air temperature is favourable for obtaining best quality roots (Singh and Bhandari, 2015). Bolting refers to the appearance and elongation of inflorescence axis, accompanied by stem lengthening (Chen *et al.*, 2019). Bolting occurs when the energy reserves are diverted for the production of flowering stems instead of economic parts like roots and leaves due to which flowering stems are produced prematurely (Kamenetsky and Rabinowitch, 2001). Bolting has been reported to be induced by production of endogenous gibberellins (GAs) in plants and application of GAs (Mauromicale *et al*., 2000) and controlled by use of gibberellin biosynthesis inhibitor like Uniconazole, Paclobutrazol, Abscisic Acid (Rademacher, 2000; Jabir *et al*., 2017). Maleic hydrazide (MH), chemically known as 1,2- dihydro-3,6-pyridazinedione is an herbicide and a growth retardant (Marcano *et al*., 2004).

Premature bolting affects the vegetative growth and causes reduction in harvest yield and quality (Jung and Müller, 2009; Kitashiba *et al.*, 2014). Bolting is the major problem of radish cultivation. It occurs due to high temperature (Khokhar, 2008), day length variation or variation in photoperiod (Wu *et al*., 2016), water and nutrient stress (Díaz-Pérez *et al.*, 2003; El Balla *et al.*, 2013). The experiment was conducted hypothesizing the possible effects of Maleic Hydrazide on bolting behaviour of radish. Thus, in an attempt to provide assessable solution for managing bolting during late season cultivation in Terai region, the effects of different concentrations of Maleic Hydrazide on bolting behaviour of radish was investigated.

Materials and Methods:

Plant and chemical materials:

Seeds of Tokinashi cultivar of radish, a medium-time bolter, it is produced and marketed by SEAN Seed Service Centre Ltd., Nepal and Maleic Hydrazide (98% w/w) was manufactured at H.I. Media Laboratories, Mumbai, India.

Experimental site:

A field experiment was conducted in Siddharthanagar, Rupandehi, Nepal (27° 29' 3.3072" N, 83° 27' 13.3884" E and elevation 105 masl) during late winter season (January-March) in a field that was fallow for one year.

Experimental setup:

Field experiment was laid out on Randomized Complete Block Design (RCBD) individual plot size was 1.2m×2m (2.4m^2). Distance between consecutive rows and plants in a row maintained at 20 cm each.

Treatments:

Eight different concentrations of Maleic Hydrazide (MH) viz. 0, 0.025, 0.05, 0.1, 0.2, 0.25, 0.3 and 0.5 percent were used as treatments. 0% MH concentration was used as control where water was foliar sprayed.

Preparation of treatments:

For obtaining different concentrations of MH, required amount of 1% stock solution was prepared and then diluted with calculated amount of water.

Treatment application:

Different concentrations of MH thus prepared, were applied on February 18th 2018 at 49 days after sowing (DAS). Single uniform foliar application was done with the help of hand sprayer of 2 L capacity @2L/2.4m^2.

Parameters recorded:

Plant height (cm), No. of leaves per plant, root yield (kg ha^{-1}), harvested at appearance of first bolted plant), days to first bolted plant, days to 25% bolted plants, days to 50% bolted plants and bolted plants at 91 DAS and 98 DAS were recorded from 10 sample plants per plot.

Statistical analysis:

Data collected were statistically analyzed by using M-STATC. ANOVA and DMRT were performed at 5 % level of significance.

Results and Discussion:

No. of Leaves plant^{-1}

No. significant effect of Maleic Hydrazide concentrations was observed on no. of photosynthetically active leaves per plant at various days after treatment (DATrt). But in terms of % change (increment/reduction) in no. of leaves, least increment of no. of leaves per plant was recorded for treatment at 0% MH (24.73%) and highest (34.38%) at 0.5% MH concentration at 7 DATrt. But at 14 DATrt, highest increment was recorded at 0% MH (15.31%) and least at 0.3% MH (7.80%). Similarly, at 21 DATrt, maximum increment was found at 0.05% MH (10.53%) and minimum at 0.5% MH (Fig. 1). Decrease in no. of leaves was observed at 28 DATrt. The reduction in no. of leaves at 28 DATrt might also be due to removal of older leaves. The reduction in no. of leaves was maximum for 0.5% MH and minimum for 0 % MH (Fig. 1). The lesser difference in no. of leaves up to 21 DATrt and higher negative difference at 28 DATrt, with increasing MH concentration might be due to retardative effect of MH on cell growth, division and respiration of meristematic tissues (Marcano *et al.*, 2004). The results obtained contrasted with that by Patil *et al.,* (2008) in okra, but are in accordance to that by Zeb *et al.,* (2015) in chrysanthemum and Shedgel *et al.,* (2008) in sweet potato.

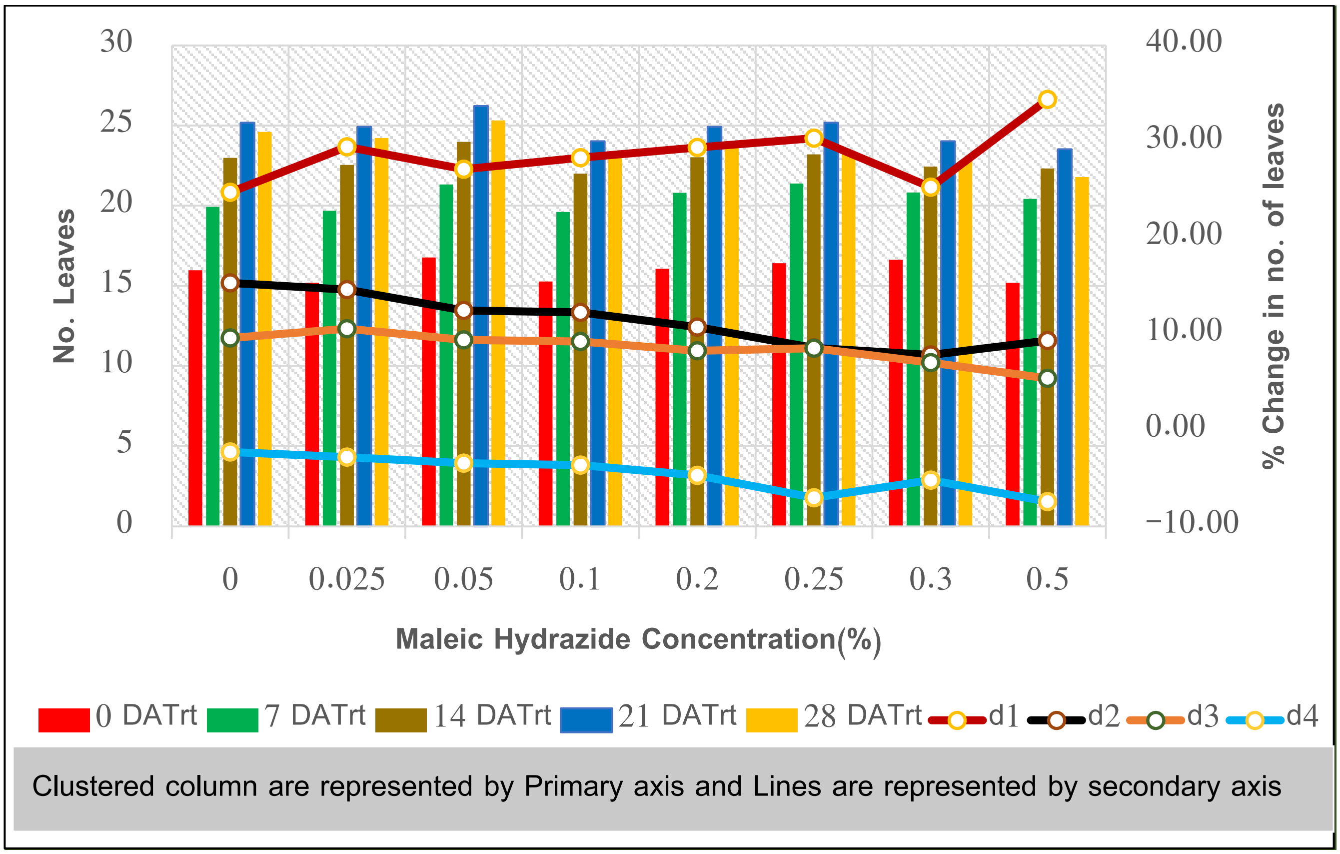

Fig. 1: Effect of different concentrations of Maleic Hydrazide (%) on No. of Leaves per plant of Radish cv. Tokinashi at Rupandehi, Nepal, 2018

Note: DATrt=Days after Treatment (MH Application), d1, d2, d3, d4=Difference in no. of leaves (%) between successive days of treatment application i.e. d1= [(No. of leaves at 7 DATrt-No. of leaves at 0 DATrt)*100/No. of leaves at 0 DATrt]

Plant Height (cm)

MH concentration was found to have significant effect on plant height (cm). At 0 DATrt, maximum plant height was measured at 0.5% MH (27.3 cm), which didn't vary statistically ($p>0.05$) to that at 0.3% MH, but differed statistically ($p<0.05$) to that at other concentrations. At 7 DATrt, Maximum plant height was obtained at 0.3% MH (32.025 cm), which didn't vary statistically ($p>0.05$) to that at 0.5% and 0.05% concentration, but varied statistically ($p<0.05$) to that at other concentrations. At 14 DATrt, maximum height was observed at 0.3% MH (32.6 cm) which statistically varied ($p<0.05$) to that at 0% MH or control. At 21 DATrt, tallest plant was measured at 0.05% MH (33.5 cm) and smallest at 0 % MH or control (30.1 cm). At 28 DATrt, maximum height was found at 0.05% MH and minimum at 0% concentration (Fig. 2).

From plant height only, relationship between MH concentration (%) and plant height cannot be clearly depicted. Thus, the relationship can be justified to some extent on the basis of % change of plant height (increment/reduction) at 0 DATrt, 7 DATrt, 14 DATrt, 21 DATrt, 28 DATrt (Fig. 2). Least increment (%) of plant height was recorded for treatment at 0.5% MH (15.47%) and highest (21.22%) at 0% MH concentration at 7 DATrt. Similarly, at 14 DATrt, highest increment in plant height was recorded at 0% MH (7.11%) and least increment at 0.3% MH concentration (1.79%). At 21 DATrt, highest increment was at 0% MH (5.24%) and least at 0.25% MH (1.95%). Maximum reduction was recorded at 0.5% MH (5.85%) and minimum at 0.025% MH (0.91%) (Fig. 2). The reduced increment in plant height might be due to the action of MH as growth retardant inhibiting the gibberellin biosynthesis which plays role in shoot elongation (Latimer, 2009; Malik *et al*., 2017). MH also reduces the activity of Auxin, which subsequently reduces cell division. The results are in resonance with that obtained by Sonkar, (2003) in pumpkin, Thappa, (2011) in cucumber, Kumar and Ughreja (1998), Zeb *et al.*, (2015) in chrysanthemum, Shedgel *et al.*, (2008) in sweet potato.

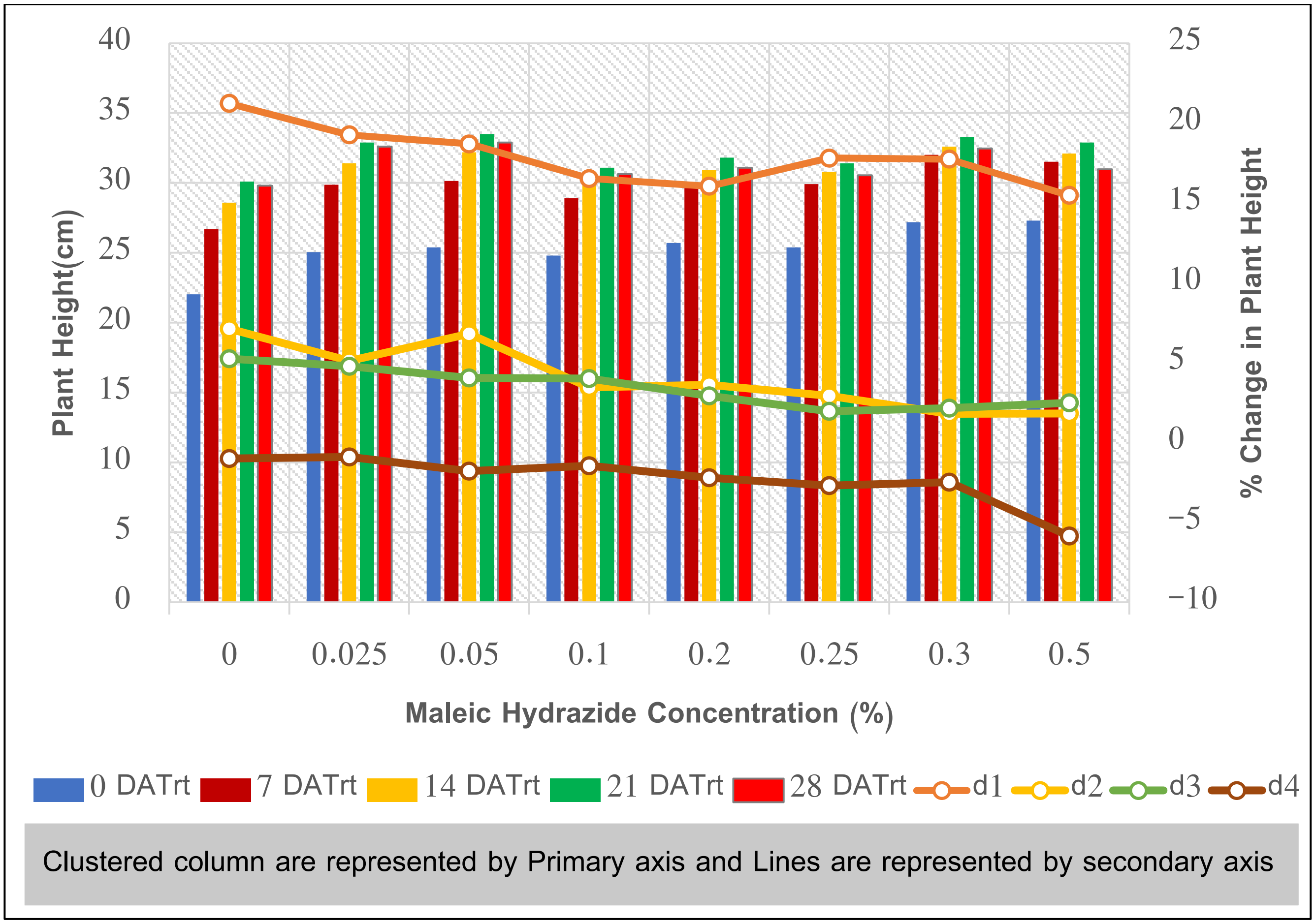

Fig. 2: Effect of different concentrations of Maleic Hydrazide (%) on Plant Height (cm) of Radish cv. Tokinashi at Rupandehi, Nepal, 2018

Note: DATrt=Days after Treatment (MH Application), d1, d2, d3, d4-% change in plant height between successive days of treatment application i.e. d1= [(Plant height at 7 DATrt-Plant height at 0 DATrt)*100/Plant Height at 0 DATrt]

Total Root Yield

Root Yield obtained was significantly different at different MH concentrations (Fig. 3). Highest root yield was obtained at 0.25% MH concentration (44.8 t ha^{-1}) and it was statistically significant ($p<0.05$) to least yield *0% MH concentration. Lowest economic yield (root yield) was obtained at 0% MH concentration or control, which varied statistically ($p<0.05$) to that at 0.25% MH concentration. The increase in root yield may be due to partition distribution of nutrients and carbohydrate reserves towards the underground roots rather than the shoots. The inhibition of plant growth in the up-ground parts must have resulted due to foliar spraying. The results are in partial agreement with that obtained by Venezian *et al.*, (2017) in tomato, who suggested the influence of increasing MH concentration on economic yield. Similar trend can be observed by Shedge *et al.*, (2008) in sweet potato, Sonkar (2003) in pumpkin, Hidayatullah *et al.*, (2012) in bottle gourd, Thappa *et al.*, (2011) in cucumber and Sindhu and Neelamegam, (2009) in okra.

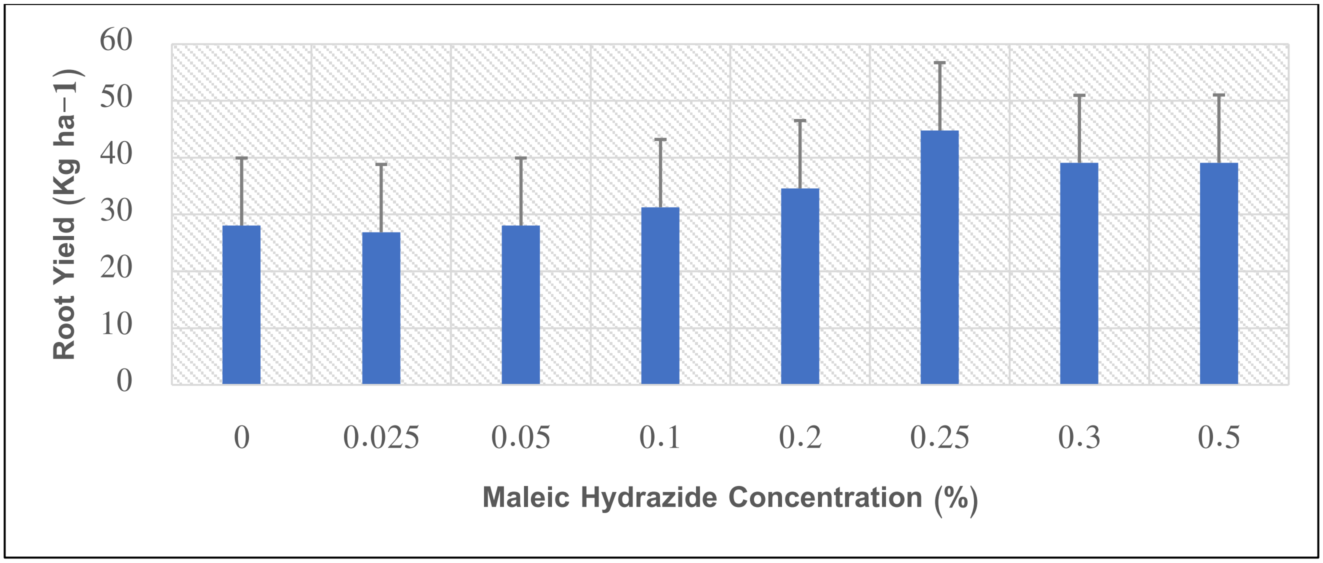

Fig. 3. Effect of different concentrations of Maleic Hydrazide (%) on root yield of Radish cv. Tokinashi at Rupandehi, Nepal, 2018

Days to bolting

Days to bolting were significantly affected by different concentration of Maleic Hydrazide. Increasing concentration of Maleic Hydrazide concentration significantly delayed the days to first bolted plant, days to 25% bolted plants, days to 50% bolted plants. First bolted plant was recorded earliest at 0% MH concentration (77.33 days) and last at 0.5% MH concentration (87.33 days), which didn't vary statistically ($p>0.05$) to that at 0.3% MH concentration. 25% plants bolted earliest at 0% MH concentration (85.33 days) and last at 0.5% concentration. Also, similar results were recorded for Days to 50% bolted plants (Fig. 4).

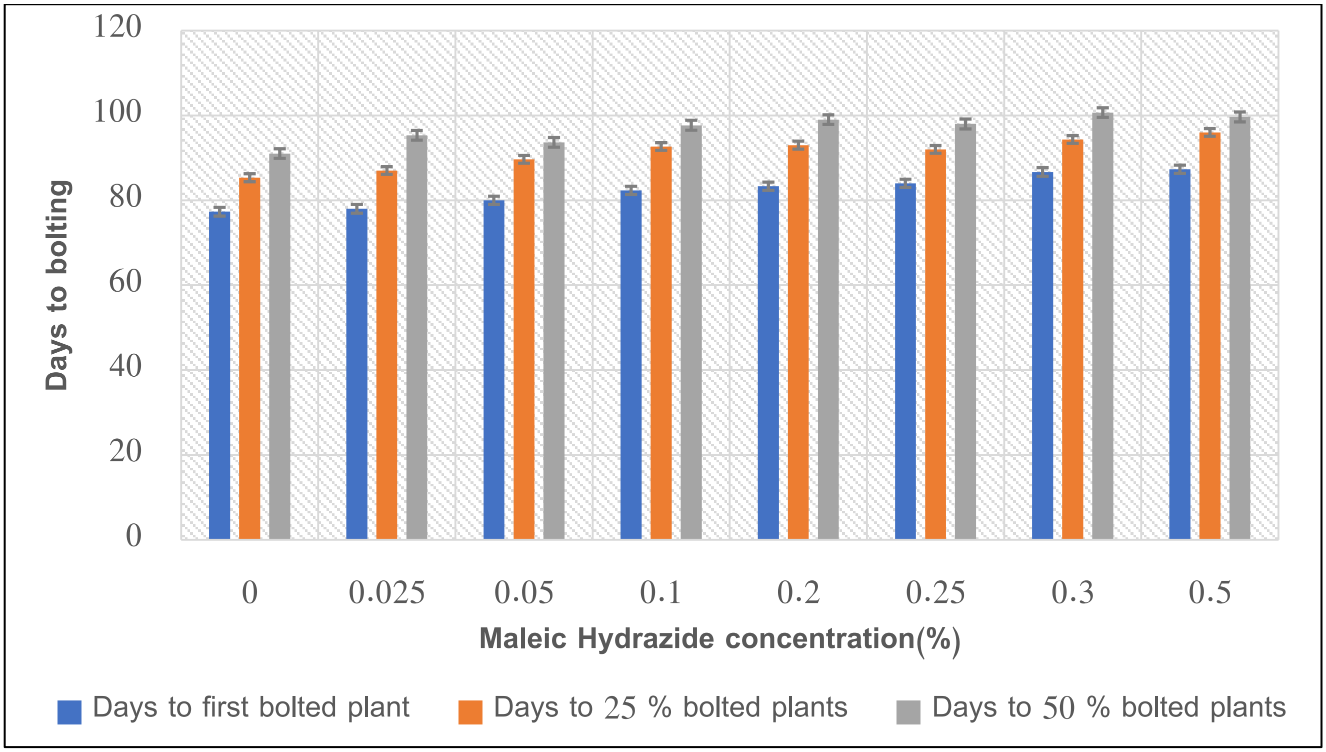

Fig. 4: Effect of different concentrations of Maleic Hydrazide (%) on days to bolting (Days to first bolted plant, days to 25% bolted plants and days to 50% bolted plants) of Radish cv. Tokinashi at Rupandehi, Nepal, 2018

Bolted Plants Per plot

Effect of different MH concentrations on bolted plants was not significant at 91 DAS (42 DATrt) but significant at 98 DAS (49 DATrt). At 91 DAS, highest number of plants bolted at control (4.667) and least number at 0.3 and 0.5 % MH concentration. At 98 DAS, most plants bolted at 0% and 0.05% MH concentration, which was statistically similar ($p>0.05$) to that at 0.025% and 0.1% MH concentration. Least plants bolted at 0.5% MH concentration (3.333) which was statistically similar ($p>0.05$) to that at 0.3%, 0.25% and 0.2% MH concentration (Table 1). Number of bolted plants at control and 0.05 % concentration was found to be statistically different ($p<0.05$) than of concentration greater than 0.2%. No significant difference was observed between concentrations up to 0.1 % concentration and concentration greater than 0.2 % concentration.

The delayed appearance of floral inflorescence with increasing concentration might have resulted inhibitive action of Maleic Hydrazide (sprayed on the shoots) on gibberellin biosynthesis, thereby reduction in cell division and cell elongation. The results are in consonance with that by Malik et al. (2017) in chrysanthemum and Singh *et al.*, (2019) in gerbera.

Table 1: Effect of different concentrations of Maleic Hydrazide (%) on average bolted plants of radish cv. Tokinashi

MH concentration (%)	Average bolted plants	
	91 DAS (42 DATrt)	98 DAS (49 DATrt)
0.5	1	3.333[D]
0.3	1	4[CD]
0.25	1.333	4[CD]
0.2	1.667	4.333[BCD]
0.1	2.333	5[ABC]
0.05	3	5.667[A]
0.025	3.667	5.333[AB]
0 (control)	4.667	5.667[A]
SEm±	0.2182	0.3700
LSD (0.05)	NS	1.123
CV (%)	16.20	13.73
Grand Mean	2.333	4.667

Note: DAS=Days after sowing, DATrt=Days after Treatment(MH application)

Economics of Cultivation:

The cost of cultivation includes cost for seed, manures and fertilizers, labour, plant protection measures and Maleic Hydrazide. The only cost varying is the cost of Maleic Hydrazide (MH) for each treatment. Cost of cultivation was highest for treatment at 0.5% MH concentration and least for treatment at 0% MH concentration (control) but Gross Return and Net Return were highest for treatment at 0.25% MH concentration and lowest for treatment at 0.025% MH concentration. The B:C ratio was highest for treatment at 0.25% MH concentration (2.75), followed by treatment at 0.3% (2.27) and the least was for treatment at 0.025% MH concentration.

Table 2: Effect of different MH concentration on cost of cultivation, cross return, net return and B:C ration

Treatments (MH %)	Cost of cultivation (NRs ha^{-1})	Gross return (NRs. ha^{-1})	Net return (NRs. ha^{-1})	B: C ratio
0.5	437500	1232000	794500	1.82
0.3	412500	1348000	935500	2.27
0.25	406250	1524000	1117750	2.75
0.2	400000	1200800	800800	2.00
0.1	387500	825000	437500	1.13
0.05	381250	765000	383750	1.01
0.025	378125	617500	239375	0.63
0	375000	650000	275000	0.73

Conclusion:

From the above results, Maleic Hydrazide was found to influence growth parameters: No. of leaves per plant and Plant Height, Root Yield and Days to bolting of radish. Maleic hydrazide application at and above 0.2% concentration positively influenced the parameters but 0.25% Maleic Hydrazide concentration was found to be superior than other treatments with respect to inhibition of growth, increment in yield, delayed bolting and maximum B:C Ration. The experiment must be replicated for several times and at multiple locations for the proper validation of the results obtained.

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تأثير معاملة نبات اللفت (Raphanus sativus cv. Tokinashi) بمادة ماليك هيدرازيد ما قبل الحصاد في صفات النمو والغلة والشمرخة خلال الموسم الشتوي تحت ظروف روبانديهي، نيبال

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الملخص

نفذت التجربة في روبانديهي، نيبال في الفترة من شهر كانون الثاني وحتى شهر آذار من العام 2018، بهدف دراسة تأثير عدة تراكيز (0، 0.025، 0.05، 0.1، 0.2، 0.25، 0.3 و0.5%) من ماليك هيدرازيد (MH)، رشاً على المجموع الخضري بمعدل 2 لتر لكل 2.4 م2، بعد 49 يوم من الزراعة، في صفات النمو، والغلة، والشمرخة لنبات اللفت. نفذت التجربة وفق تصميم القطاعات الكاملة العشوائية، بأربعة مكررات. أثر ماليك هيدرازيد في كل من ارتفاع النبات وعدد الأوراق في النبات الواحد، وقد أعطى النبات أعلى غلة من المجموع الجذري (44.8 طن/هكتار) عند الرش بتركيز (0.25%)، في أعطى أقل غلة من الجذور (26.07%) عند الرش بتركيز (0.025%). كما بينت النتائج تأخر النبات في الشمرخة وبشكل معنوي ($p<0.05$) بارتفاع تركيز الرش بمادة ماليك هيدرازيد، وقد تفوق التركيز (0.25%) على بقية التراكيز المدروسة في تأخير النمو وازدياد الغلة. توصي الدراسة بتكرار التجربة لتأكيد النتائج المتحصل عليها.

الكلمات المفتاحية: الموسم الشتوي المتأخر، ماليك هيدرازيد، تأخر النمو، تأخر الشمرخة.